U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

9.3.2 PROCESS AND POST-ACCIDENT SAMPLING SYSTEMS

REVIEW RESPONSIBILITIES

Primary - Chemical Engineering Branch (CMEB)

Secondary - None

I. AREAS OF REVIEW

CMEB reviews the following information in the applicant's safety analysis report (SAR):

1. The design objectives and design criteria for the process sampling system (PSS) and post-accident sampling system (PAS) are reviewed at the construction permit (CP) stage. During the operating license (OL) stage of review, CMEB review consists of confirming the design accepted at the CP stage and evaluating the adequacy of the applicant's technical specifications in these areas. The review includes identification of the process streams to be sampled and the parameters to be determined through sampling (e.g., gross beta-gamma concentration, boric acid concentration).

2. The system descriptions for the PSS and PAS are reviewed at the operating license (OL) stage. The review includes (a) piping and instrumentation diagrams (P&IDs), (b) provisons for obtaining representative samples, (c) location of sampling points and sample stations, and (d) provisons for purging sampling lines.

3. The seismic design and quality group classifications of piping and equipment, and the bases for the classifications chosen are reviewed at the CP stage. At the OL stage, the review includes design and expected temperatures and pressures and materials of construction of components of the system.

4. The isolation provisions for the system and the means provided to limit radioactive releases by limiting reactor coolant losses are reviewed at the CP stage.

5. The design of the post-accident sampling system and the operational procedures of post-accident sampling for the reactor coolant and containment atmosphere

are reviewed to determine the capability of promptly obtaining samples, under accident conditions, for chemical and radiochemical analyses.

CMEB coordinates reviews related to this system that are performed by the following branches as part of their primary review responsibilities: Radiological Assessment Branch (RAB), under SRP Section 12.3, reviews the potential personal radiation exposure during post-accident sampling. Effluent Treatment Systems Branch (ETSB) reviews the ventilation systems which may be operating during post-accident sampling and the sampling and monitoring systems for radwaste processing systems under SRP Sections 11.3 and 11.5, respectively. Containment Systems Branch (CSB), under SRP Section 6.2.4, verifies that remotely operated containment isolation valves in the PSS and PAS are designed to close on a containment isolation signal (CIS) or safety injection signal (SIS). Instrumentation and Control Systems Branch (ICSB), under SRP Section 7.3, verifies that an override capability exists for the containment isolation valves which will be used for post-accident sampling of the reactor coolant, containment sump water, and containment atmosphere without clearing the CIS or SIS. Power Systems Branch (PSB), under SRP Section 8.3.1, ensures that power supplies shall be available to all remotely operated valves in the PAS, after detection of an accident which requires containment isolation, assuming a concurrent loss of offsite power. Equipment Qualification Branch (EQB), under SRP Section 3.11, verifies that those valves which are inaccessible during an accident are environmentally qualified to ensure operability under accident conditions. Auxiliary System Branch (ASB), under SRP Section 3.6.1, reviews the design with respect to the effects of externally or internally generated missiles, pipe whip, and jet impingement forces associated with postulated pipe breaks in high energy fluid systems or leakage cracks in moderate energy fluid systems.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

CMEB acceptance criteria are based on meeting the relevant requirements of the following regulations:

A. 10 CFR Part 20, § 20.1(c) as it relates to making every reasonable effort to maintain radiation exposures as low as is reasonably achievable.

B. General Design Criterion 1 as it relates to the design of the PSS and PAS and components to standards commensurate with the importance of their safety functions.

C. General Design Criterion 2 as it relates to the PSS and PAS being able to withstand the effects of natural phenomena.

D. General Design Criterion 13 as it relates to monitoring variables that can affect the fission process, the integrity of the reactor core, and the reactor coolant pressure boundary.

E. General Design Criterion 14 as it relates to assuring the integrity of the reactor coolant pressure boundary.

F. General Design Criterion 26 as it relates to controlling reliably the rate of reactivity changes.

G. General Design Criterion 41 as it relates to reducing the concentration and quality of fission products released to the environment following postulated accidents.

H. General Design Criterion 60 as it relates to capability of the PSS and PAS to controlling the release of radioactive materials to the environment.

I. General Design Criterion 63 as it relates to detecting conditions that may result in excessive radiation levels in the fuel storage and radioactive waste systems.

J. General Design Criterion 64 as it relates to monitoring the containment atmosphere and plant environs for radioactivity, and

K. Clarifications of Section II.B.3 in NUREG-0737.

Specific criteria and guidelines of Regulatory Guides 1.21, 1.26, 1.29, 1.56, 1.97 and 8.8 are used to meet the relevant requirements of 10 CFR Part 20, § 20.1(c), General Design Criteria (GDC) 1, 2, 13, 14, 26, 41, 60, 63, and 64 in Appendix A to 10 CFR Part 50, and the clarifications of item II.B.3 in NUREG-0737, as follows:

1. The applicant's design should be such that the PSS has the capability for sampling all normal process systems and principal components, including provisions for obtaining samples from at least the points indicated below. The guidelines of regulatory position C.2 in Regulatory Guide 1.21 (reference 1) and regulatory positions C.1 and C.4.a in Regulatory Guide 1.56 (reference 2) are used to meet the requirements of the relevant General Design Criteria (GDC).

    a. For a pressurized water reactor (PWR):

	GDC
Reactor coolant (e.g., letdown system, etc.)	13, 14, 26, 64
Refueling (borated) water storage tank.	13, 26
ECCS core flooding tank.	13
Boric acid mix tank.	13, 26
Boron injection tank.	13
Chemical additive tank.	13, 14, 41
Spent fuel pool.	63
Secondary coolant (e.g., condensate hotwell)	13, 14
Pressurizer tank.	64
Steam generator blowdown (if applicable).	14, 64
Secondary coolant condensate treatment waste	64
Sumps inside containment.	64
Containment atmosphere.	64
Gaseous radwaste storage tanks.	63, 64

b. For a boiling water reactor (BWR):

Main condenser evacuation system offgas.	64
Reactor coolant (inlet and outlet of reactor water cleanup system).	13, 14, 64
Standby liquid control system tank.	13, 26
Sumps inside containment.	64
Spent fuel pool.	63
Drywell atmosphere (Mark I & II).	64
Inlet and outlet of gaseous radwaste storage tank.	63, 64
Inlet and outlet of condensate polishing system.	13, 14

Other sample points that may be included in the PSS but do not require remote sampling are given in SRP Section 11.5.

2. The required analysis and frequencies should be given in the plant technical specifications.

3. CMEB will use the following guidelines for determining the acceptability of the PSS functional design:

   a. Provisions should be made to assure representative samples from liquid process streams and tanks. For tanks, provisions should be made to sample the bulk volume of the tank and to avoid sampling from low points or from potential sediment traps. For process stream samples, sample points should be located in turbulent flow zones. The guidelines of regulatory position C.6 in Regulatory Guide 1.21, (reference 1) are used to meet these criteria.

   b. Provisions should be made to assure representative samples from gaseous process streams and tanks in accordance with ANSI N13.1-1969 (reference 3). The guidelines of regulatory position C.6 in Regulatory Guide 1.21 (reference 1) are followed to meet this criterion.

   c. Provisions should be made for purging sampling lines and for reducing plateout in sample lines (e.g., heat tracing). The guidelines of regulatory position C.7 in Regulatory Guide 1.21 (reference 1) are followed to meet this criterion.

   d. Provisions should be made to purge and drain sample streams back to the system or origin or to an appropriate waste treatment system in accordance with the requirements of 10 CFR Part 20, § 20.1(c) to keep radiation exposures as low as is reasonably achievable. The guidelines of regulatory positions 2.d.(2), 2.f.(3), and 2.f.(8) in Regulatory Guide 8.8 (reference 5) are followed to meet this criterion.

   e. Isolation valves should fail in the closed position, in accordance with the requirements of GDC 60 in Appendix A to 10 CFR Part 50 to control the release of radioactive materials to the environment.

   f. Passive flow restrictions to limit reactor coolant loss from a rupture of the sample line should be provided in accordance with the requirements of 10 CFR Part 20, § 20.1(c) to keep radiation exposures to as low as reasonably achievable and the requirements of GDC 60 in Appendix A to 10 CFR Part 50 to control the release of radioactive materials to the environment. The guidelines of position 2.i.(6) in Regulatory Guide 8.8 (reference 5) should be followed to meet this criterion. Passive flow restrictions in the sample lines may be replaced by redundant environmentally qualified, remotely operated isolation valves to limit potential leakage from sampling lines. The automatic containment isolation valves should close on containment isolation signals or safety injection signals.

4. To meet the requirements of GDC 1 and 2, the seismic design and quality group classification of sampling lines, components and instruments for both the PSS and PAS should conform to the classification of the system to which each sampling line and component is connected (e.g., a sampling line connected to a Quality Group A and seismic Category I system should be designed to Quality Group A and seismic Category I classification), in accordance with regulatory positions C.1, C.2, and C.3 in Regulatory Guide 1.26 (reference 6), regulatory positions C.1, C.2, C.3, and C.4 in Regulatory Guide 1.29 (reference 7), and the guidelines of Regulatory Guide 1.97 (reference 8). *Components and piping downstream of the second isolation valve may be* designed to Quality Group D and nonseismic Category I requirements, in accordance with regulatory position C.3 in Regulatory Guide 1.26 (reference 6).

5. The post-accident sampling system and operational procedures should meet the guidelines of item II.B.3 in NUREG-0737 (reference 9) and of Regulatory Guide 1.97 (reference 8), and the following additional clarifications:

   a. To meet the requirements of GDC 13 and 14 in Appendix A to 10 CFR Part 50, if chemical analyses show that chloride concentration in the reactor coolant exceeds the Technical Specification limits, then verification that the dissolved oxygen concentration is below the Technical Specification limits will be mandatory. Verification of hydrogen residual in excess of 10 cubic centimeters (at standard temperature and pressure) per kilogram of reactor coolant will be acceptable in lieu of direct analysis of dissolved oxygen for 20 days.

   b. To meet the requirements of GDC 60 in Appendix A to 10 CFR Part 50, if on-line gas chromatography is used for reactor coolant analyses, special provisions (e.g., pressure relief and purging) should be available to prevent high-pressure carrier gas from entering the reactor coolant.

   c. To meet the requirements of GDC 60 in Appendix A to 10 CFR Part 50, passive flow restrictions in the sampling lines may be replaced by redundant, fully qualified, remotely operated isolation valves to limit potential leakage from the sample lines. The automatic containment isolation valves should close on containment isolation signals or safety injection signals. All remotely operated valves should have assured power supplies and control so that they can be reopened after an accident without clearing the isolation signal. Valves which are inaccessible during an accident should be environmentally qualified to ensure operability under accident conditions.

III. REVIEW PROCEDURES

The reviewer will select and emphasize material from this SRP section, as may be appropriate for a particular case.

1. In the review of the process sampling system, CMEB compares the list of process sampling points contained in the SAR with the sampling points identified in Subsection II.1, above, to assure that the required process sampling points have been provided.

2. CMEB compares the capability of the system to obtain representative samples of process fluids and the locations of sampling points with the guidelines for obtaining representative samples of fluids contained in regulatory position C.6 of Regulatory Guide 1.21 (reference 1) and with the principles for obtaining representative samples of gases contained in ANSI N13.1-1969 (reference 3).

3. CMEB compares the seismic design and quality group classifications of the PSS and PAS to the classifications of the fluid systems to which the sampling system is connected.

4. CMEB reviews the technical specifications for process sampling to determine that the content and intent of the technical specifications are in agreement with the requirements developed as a result of the staff's review.

5. CMEB verifies that provisions have been made to limit the potential for reactor coolant loss from the rupture of a sample line and provides Accident Evaluation Branch with estimates of RCS fluid losses that would result from sample line rupture.

6. CMEB reviews the post-accident sampling system and operational procedures to determine compliance with the guidelines of item II.B.3 in NUREG-0737 (reference 9) and of Regulatory Guide 1.97 (reference 8), and the additional clarifications in acceptance criterion 5 above. CMEB verifies that dilution, mixing and sample collection steps will not introduce excessive analytical errors. CMEB verifies that the frequency of system functional testing will be adequate to ensure operability of the system and that operators are trained and kept proficient in the use of the system. CMEB reviews the procedure for relating radionuclide concentrations to the extent of core damage. CMEB reviews information pertaining to accuracy and sensitivity of chemical analysis procedures and on-line instrumentation under post-accident chemistry conditions (high specific sample activity and possible analytical interference due to high levels of fission products-iodine, iodide, bromide, cesium, rubidium).

IV. EVALUATION FINDINGS

CMEB verifies that sufficient information has been provided and that the review supports conclusions of the following type, to be included in the staff's safety evaluation report:

> The process and post-accident sampling systems include piping, valves, heat exchangers, and other components associated with the systems from the point of sample withdrawal from a fluid system up to the analyzing station, sampling station, or local sampling point. Our review included

the provisions proposed to sample all principal fluid process streams associated with plant operation and the applicant's proposed design of these systems. The review has included descriptive information for the process and post-accident sampling systems and the location of sampling points, as shown on piping and instrumentation diagrams. The basis for acceptance in our review has been conformance of the applicant's design for the process and post-accident sampling systems to applicable regulations, guides, and industry standards.

The staff concludes that the design of the process and post-accident sampling systems are acceptable and that the process sampling system meets the relevant requirements of 10 CFR Part 20, § 20.1(c) and General Design Criteria 1, 2, 13, 14, 26, 41 (for PWR only), 60, 63,and 64 in Appendix A to 10 CFR Part 50, and the post-accident sampling system meets the relevant requirements of General Design Criteria 1, 2, 13, 14, and 60 in Appendix A to 10 CFR Part 50 and the clarifications of Section II.B.3 in NUREG-0737. This conclusion is based on the following:

<u>For PWR</u>

The staff has determined that the proposed process sampling system meets (1) the requirements of GDC 13 in Appendix A to 10 CFR Part 50 to monitor variables that can affect the fission process for normal operation, anticipated operational occurrences, and accident conditions, by sampling the reactor coolant, the ECCS core flooding tank, the refueling water storage tank, the boric acid mix tank, and the boron injection tank for boron concentrations; (2) the requirements of GDC 13 and 14 in Appendix A to 10 CFR Part 50, to monitor variables that can affect the reactor coolant pressure boundary and to assure a low probability of abnormal leakage, rapidly propagating failure, and gross rupture, respectively, by sampling the reactor coolant and the secondary coolant for chemical impurities that can affect the reactor coolant pressure boundary; (3) the requirements of GDC 26 in Appendix A to 10 CFR Part 50 to control the rate of reactivity changes, by sampling the reactor coolant, the refueling water storage tank, and the boric acid mix tank for boron concentration; (4) the requirements of GDC 13, 14, and 41 in Appendix A to 10 CFR Part 50 to monitor variables that can affect the integrity of the reactor core and reactor coolant pressure boundary and to reduce the concentration and quality of fission products released to the environment following postulated accidents, respectively, by sampling the chemical additive tank for chemical additive concentrations, to ensure an adequate supply of chemical for meeting the material compatibility requirements and the elemental iodine removal requirements of the containment spray and recirculation solutions following a postulated accident; and (5) the requirements of GDC 64 in Appendix A to 10 CFR Part 50 to monitor for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents, by sampling the reactor coolant, the pressurizer tank, the steam generator blowdown, the secondary coolant condensate treatment waste, the sump inside containment, the containment atmosphere, and the gaseous radwaste storage tank for radioactivity.

<u>For BWR</u>

The staff has determined that the proposed process sampling system meets (1) the requirements of GDC 13 and 14 in Appendix A to 10 CFR Part 50 to monitor variables that can affect the reactor coolant pressure boundary and to assure a low probability of abnormal leakage, rapidly propagating failure, and gross rupture, respectively, by sampling the reactor coolant, and the condensate for chemical impurities that can affect the reactor coolant pressure boundary; (2) the requirements of GDC 13 and 26 in Appendix A to 10 CFR Part 50 to maintain the reactor core subcritical under cold conditions in the event that control rod system is inoperable, by sampling the standby liquid control system tank for boron concentration; and (3) the requirements of GDC 64 in Appendix A to 10 CFR Part 50, to monitor for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents, by sampling the reactor coolant, the main condenser evacuation system offgas, the sump inside containment, the drywell atmosphere, and the gaseous radwaste storage tank for radioactivity.

For both PWR and BWR

The staff has further determined that the proposed process sampling system meets (a) the requirements of 10 CFR Part 20, § 20.1(c) to keep radiation exposures to as low as is reasonably achievable and of GDC 60 in Appendix A to 10 CFR Part 50 to control the release of radioactive materials to the environment, by purging and draining sample streams back to the system or origin or to an appropriate radwaste treatment system, and by providing either redundant isolation valves that fail in the closed position or passive flow restrictions in the sampling lines; and (b) the requirements of GDC 63 in Appendix A to 10 CFR Part 50, to detect conditions that may result in excessive radiation levels in fuel storage and radioactive waste systems, by sampling the spent fuel pool water and the gaseous radwaste storage tank for radioactivity.

The staff also has determined that the proposed process sampling and post-accident sampling systems meet the quality standards requirements of GDC 1 and the seismic requirements of GDC 2 in Appendix A to 10 CFR Part 50, by designing the sampling lines and components of the process and post-accident sampling systems to conform to the classification of the system to which each sampling line and component is connected, in accordance with the regulatory positions C.1, C.2, and C.3 of Regulatory Guide 1.26, the regulatory positions C.1, C.2, C.3, and C.4 of Regulatory Guide 1.29, and the guidelines of Regulatory Guide 1.97.

In addition, the staff has determined that the proposed post-accident sampling system meets (1) the clarifications of item II.B.3 in NUREG-0737 by providing a sampling program to obtain and analyze promptly samples from the reactor coolant and the containment atmosphere, for radionuclides which may be indicators of the degree of core damage and for dissolved gases, chloride and boron concentrations in liquids, following a postulated accident, in accordance with the guidelines of Regulatory Guide 1.97; (2) the requirements of GDC 13 and 14 in Appendix A to 10 CFR Part 50, to monitor variables which can affect the integrity of the reactor core and the reactor coolant pressure boundary for accident conditions, and to assure a low probability of abnormal leakage, rapidly propagating failure, and gross rupture, respectively, by keeping the oxygen concentration in the reactor coolant below the Technical Specification limits when the chloride concentration exceeds the Technical Specification limits, or by having excessive hydrogen dissolved in the reactor coolant; and (3) the requirements of GDC 60 in Appendix A to 10 CFR Part 50 to control the release of radioactive materials to the environment, by preventing high-pressure carrier gas used in gas chromatographic analysis of reactor coolant from entering the reactor coolant, and by providing passive flow restrictions or fully qualified, remotely operated isolation valves in the sampling lines, to limit potential leakage from the sampling lines.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides and NUREG.

VI. REFERENCES

1. Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants."

2. Regulatory Guide 1.56, "Maintenance of Water Purity in Boiling Water Reactors."

3. ANSI N13.1-1969, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities," American National Standards Institute (1969).

4. Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," LWR Edition.

5. Regulatory Guide 8.8, "Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable."

6. Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants."

7. Regulatory Guide 1.29, "Seismic Design Classification."

8. Regulatory Guide 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plants to Assess Plant and Environs Conditions during and following An Accident."

9. NUREG-0737, "Clarifications of TMI Action Plan Requirements."

10. 10 CFR Part 50, Appendix A, General Design Criterion 1, "Quality Standards and Records."

11. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

12. 10 CFR Part 50, Appendix A, General Design Criterion 13, "Instrumentation and Control."

13. 10 CFR Part 50, Appendix A, General Design Criterion 14, "Reactor Coolant Pressure Boundary."

14. 10 CFR Part 50, Appendix A, General Design Criterion 26, "Reactivity Control System Redundancy and Capability."

15. 10 CFR Part 50, Appendix A, General Design Criterion 41, "Containment Atmosphere Cleanup."

16. 10 CFR Part 50, Appendix A, General Design Criterion 60, "Control of Releases of Radioactive Materials to the Environment."

17. 10 CFR Part 50, Appendix A, General Design Criterion 63, "Monitoring Fuel and Waste Storage."

18. 10 CFR Part 50, Appendix A, General Design Criterion 64, "Monitoring Radioactivity Releases."